****

**New candidate Sorghum varieties for the semi-arid agro-ecologies of central Tanzania**

**Proposal for submission to variety release committee**

**ICRISAT ESA Sorghum Breeding programme**

**July 2018**



Table of Contents

[**Acknowledgements** ii](#_Toc517704213)

[**Summary** iii](#_Toc517704214)

[**1. Background** 4](#_Toc517704215)

[**2. Study Highlights** 4](#_Toc517704216)

[**2.1 The test genotypes** 4](#_Toc517704217)

[**2.2 Description of study locations** 5](#_Toc517704218)

[**2.3 Key results** 6](#_Toc517704219)

[**3. Detailed Narrative Report** 6](#_Toc517704220)

[**3.1. On station evaluation of genotypes ARI-Hombolo** 6](#_Toc517704221)

[**3.1.1 Performance during the 2013-14 cropping season** 7](#_Toc517704222)

[**3.1.2 Performance during the 2014-15 cropping season** 8](#_Toc517704223)

[**3.1.3 combined analysis for 2013-14 and 2014-15 seasons** 9](#_Toc517704224)

[**3.1.4 Genotype x Environment interaction** 10](#_Toc517704225)

[**3.2. On farm evaluation of genotypes** 11](#_Toc517704226)

[**3.2.1 Farmers’ traits** 11](#_Toc517704227)

[**3.2.2 Performance during the 2013-14 cropping season** 12](#_Toc517704228)

[**3.2.3 Performance during the 2014-15 cropping season** 13](#_Toc517704229)

[**3.2.4 Combined analysis for 2014-14 and 2014-15 cropping seasons** 14](#_Toc517704230)

[**3.2.5 Performance during the 2015-16 cropping season** 15](#_Toc517704231)

[**3.2.6 Performance during the 2016-17 cropping season** 16](#_Toc517704232)

[**3.2.7 Combined analysis for 2015-16 and 2016-17 cropping seasons** 17](#_Toc517704233)

[**4.0 Conclusions** 18](#_Toc517704234)

[**5.0 Appendices** 18](#_Toc517704235)

**Acknowledgements**

This research activity, in its entirety, was funded through the USAID supported Africa RISING project, led by the International Institute of Tropical Agriculture (IITA) through a sub grant to the International Crops Research Institute for the Semi-arid tropics (ICRISAT).

Implementation on-farm and on-station was done in partnership with the Government of Tanzania’s Ministry of Agriculture Department of Research Agricultural Research Institute at Hombolo. The District Agriculture Irrigation and Cooperatives Offices of Kongwa, Iringa and Kiteto districts and their respective local governments are acknowledged for their unwavering support. Members of the Research Team are shown in Appendix 2.

The support by farming communities of Mlali, Moleti, Laikala and Chitego villages (Kongwa District); Njoro and Kiperesa villages (Kiteto District) and Igula (Iringa District) is acknowledged. Plate 2 shows project Team meeting Iringa District Officials.

**Summary**

Manyara and Dodoma regions receive an average of 500 to 700 mm of precipitation per year in good years, but may receive less than 300 mm in bad cropping years. Through Africa RISING, ICRISAT and the Department of Agricultural Research Institute (ARI) at Hombolo have been testing new varieties of cereals targeted for these semi-arid agro-ecologies. The studies were conducted between 2013 and 2017 cropping seasons done on farm and on station in the region. Twenty-five (25) candidate materials identified from ICRISAT ESA sorghum breeding program from the regional adaptability trials were evaluated against the most popular commercial variety *Kari Mtama* and Lugugu a local land race. On farm testing was done in Mlali, Moleti, Laikala and Chitego (Kongwa District) and Njoro in Kiteto District. From the 2016-17 season this activity expanded to Kiperesa village in Kiteto and Igula in Iringa.

Main traits for this evaluation included; grain yield, days to 50% flowering, agronomic score, 100g seed mass, number of panicles and seedling vigour. Five genotypes (Gambella 1107, IESVs 23010 DL, 92028 DL, 92008, and 23006 DL) showed good promise both on station (AR—Hombolo) and on farm and may be considered for release. For two seasons running, Gambella 1107 had the highest yield with an average of 1840 kg/ha compared to 1353 and 1693 kg/ha for Lugugu (farmer check) and Kari Mtama 1 a released check respectively. The new genotypes also performed better in terms of 100g seed mass, number of panicles as well as resistance to leaf blight. Main traits farmers used for evaluation included; panicle size, drought tolerance, seed size and earliness. These genotypes were also the most preferred for panicle size (yield), good seed size, drought tolerance and earliness. Yield advantage of up to 100% were also observed on farmers’ fields. These lines if released, would contribute massively to food, income and nutrition security in this Region. Of the seven villages; Laikala, Moleti and Igula are the driest with rainfall below 300mm per annum and targeting these materials to such villages and those with similar climatic conditions in the Region may be very critical to unlocking productivity and alleviating the current food shortage.

Plate 1. Pictures of some of the new resilient genotypes submitted for variety release identified from research undertakings in the semi-arid ecologies of Tanzania.

 

# **1. Background**

The crop- livestock farming systems in semi-arid agro-ecologies of central Tanzania are in general characterised by low productivity, fragile production-to-market systems, and 3) vulnerability to weather and other natural disaster related challenges. Through Africa RISING, ICRISAT and the Department of Agricultural Research Institutes at Nalendele and Hombolo have been testing new varieties of legumes and cereals targeted for these semi-arid agro-ecologies. These regions receive an average of 500 to 700 mm of precipitation per year in good years, but may receive less than 300 mm in bad cropping years. Traditional crops like sorghum are well adapted to the agro-ecologies of this semi-arid area making them more resilient to climate shocks than maize. However, when compared to maize, sorghum tend to give low yields and lives the farmer in a difficult situation to decide between relatively secure but low yields of sorghum and relatively insecure but high yields of maize. Introducing high yielding sorghum varieties would be key to providing better options to the farming community that will unlocking productivity but also contribute to improved nutrition security as sorghum is rich in iron and zinc in addition to calories.

In 2013, under the project titled, “*Intensification of Cereal-legume based systems in the semi-arid areas of Tanzania to increase farm productivity and improve the farming natural resource base,*” the team begun to undertake strategic studies to develop new adapted material for the semi-arid ecologies of central Tanzania. The work was guided by a broader research hypothesis i.e. *participatory deployment of new agricultural innovations; high yielding resilient varieties and appropriate production practices could catalyse and sustain improvements, with wide benefits to the majority of semi-arid populations.* This report contains major results that emanated from the R&D Investments.

# **2. Study Highlights**

All these materials were derived from the Sorghum Breeding Program for East and Southern Africa centred at ICRISAT-Nairobi. They were selected for their wide adaptation.

## **2.1 The test genotypes**

Twenty-five (25) genotypes accessed by the project from ICRISAT Nairobi, the centre for cereals (Sorghum and Pearl millet) breeding in the Region were evaluated. Table 1 below only highlights descriptions of five (5) genotypes that had shown great promise both on station and on farm. The genotypes show to be medium to quick medium maturing. Such genotypes have an average of about 65 days to 50% flowering.

**Table 1. Description of candidate sorghum lines evaluated for release in Central semi-arid ecologies of Tanzania based on this research activity.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Genotype | Colour | Days to 50% flowering | 100g seed mass | No of panicles |
| Gambella 1107 | 1 (white) | 67 | 3 | 51 |
| IESV 23010 | 4 (brown) | 69 | 3.75 | 40.75 |
| IESV 92028 | 4 (brown) | 68.8 | 3.2 | 42.75 |
| IESV 23006 | 4 (brown) | 67.5 | 3 | 41 |
| IESV 92008 | 4 (brown) | 68.35 | 3.3 | 42.75 |
| Kari Mtama (Released check) | 1 (White) | 67 | 3 | 42 |
| Lugugu (Local check) | 1 (White) | 77.7 | 1.75 | 39.75 |

## **2.2 Description of study locations**

**The agro-ecology**: Studies were conducted on-station at ARI-Hombolo and on-farm in the districts of Kongwa (Mlali, Moleti, Laikala and Chitego) and Kiteto (Njoro village) in Tanzania (Figure 1). Kongwa district is in Dodoma region which lies at 60 10’S, 35O 45’E and 1120 m above sea level with total annual precipitation averaging 556 mm per year. Kongwa District is a typical semi-arid agro-ecology with temperatures averaging about 28OC and annual precipitation of 400-550 mm[[1]](#footnote-1)). Kiteto district is in Manyara Region, with weather conditions varying from semi-arid to sub-humid. The annual precipitation averages about 682 mm with temperatures of about 19.50C and altitude ranging from 800-2000 m above sea level. The rainfall, however in Kongwa and Kiteto between 2013 and 2016 recorded on farmers’ fields averaged 202.36 mm per pear (Appendix 1). A soil-health survey conducted in 2015 in both districts, indicated that soils in the focus villages had very low organic matter (0.17-2%) and other major nutrients, with pH ranging from 4-6 (Appendix 3).



Fig 1 Central Tanzania showing target Districts

**Demand**: A Farmer Research Network[[2]](#footnote-2) approach was used to investigate how cropping systems and socio-economic dynamics in farming communities influence adoption of improved varieties in Central Tanzania. The study was conducted in Kongwa and Kiteto involving 65 households who provided insights on cropping systems and related social dynamics. The study shows that maize, sorghum, pigeon pea, groundnut pearl millet and sunflower are the major crops in the both districts. Yield estimate for sorghum and maize intercrops are low with a combined yield of between 450-770 kg/ha. The study also showed that land is mainly owned by men with the exception of Moleti where >65%of women own land.

**Seed systems:** A project study conducted in Kongwa and Kiteto revealed that the Region has a relatively weak to moderate seed system. Only about 10% of farmers use improved or quality declared seed underpinning the fact that farmers lack sufficient options for improved varieties and where to access them (Fig2). Innovation platform meetings involving all project stakeholders from farmers to District Councils also confirmed lack of improved seeds as one of the major challenges limiting production.

**Fig 2 seed sources in Kongwa and Kiteto, source: Africa RISING report 2014**

## **2.3 Key results**

Results presented are based on evaluations of twenty-five (25) genotypes which include two local checks, on-station as well as on-farmers’ fields between 2013 and 2017. The set of twenty-five was evaluated for two seasons (2013-14 and 2014-15) at ARI Hombolo while a few selected lines were evaluated on farmers’ fields between 2013 and 2017. In the first two seasons of on farm testing, 5 genotypes were evaluated against Kari Mtama 1 (a released check) and Lugugu (farmers’ check) while the latter two seasons, 3 farmer chosen genotypes were further tested against the farmer check. Best performing genotypes that may be considered for release include; Gambella 1107, IESV 23010 DL, IESV 92028 DL, IESV 23006 DL and IESV 92008. Data used to assess performance included grain yield, days to 50% flowering, 100 g seed mass, seedling vigour, number of panicles, and disease scores (leaf blight). The test lines Gambella 1107 and IESVs 23010 DL, 92028 DL had the highest grain yield of 1840, 1657 and 1914 kg/ha respectively against 1353 and 1693 kg/ha for Lugugu and Kari Mtama 1. Gambella 1107 also showed good seed size expressed in 100g seed mass of 51g compared to 42g and 39.75g for Kari Mtama1 and Lugugu. Participatory variety selection also confirmed Gambella 1107 as the most preferred genotype especially for its yield (panicle size), seed size and tolerance to drought. In better seasons these genotypes yielded >3000kg/ha which presents great opportunity to farmers in this semi-arid Region characterized but excessive shortage of rainfall as shown in Appendix 1. One trait that that didn’t score high but often echoed by women farmers, was plant height (Plate 3). This was in reference to easiness of harvesting as the local variety grows very tall that according to them, adds a lot of drudgery to the process.

# **3. Detailed Narrative Report**

## **3.1. On station evaluation of genotypes ARI-Hombolo**

ARI-Hombolo is located at 50 75’ S and 350 95’ E with an altitude of 1062 m above sea level receiving an average rainfall of 627mm/annum.

### **3.1.1 Performance during the 2013-14 cropping season**

Results are based on eight key traits that included; grain yield, days to 50% flowering, agronomic score, 100g seed mass, number of plants lodged, number of panicles, disease score (leaf blight) and seedling vigour. In this season no significant differences were observed p<0.05 for all the traits, however Gambella 1107, IESVs 23010 and 92028 were the best yielding genotypes with yields of 1998, 1662, 1995 kg/ha respectively (Table 2). These yields were comparable to Kari Mtama 1 a newly released check but far above Lugugu a local landrace which yield of 1343kg/ha. These genotypes also yielded above the overall mean (1085kg/ha). IESV 92028 and Gambella 1107 were also better in terms of earliness with 66.5 and 69 days to 50% flowering respectively compared to 77 for the local check. This trait may be key to the Region so vulnerable to climate shocks especially unreliable rainfall that often cuts towards the end of the season or starts late and ending early entailing a short rainy season.

**Table 2 Performance during the 2013-14 cropping season**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Genotype | Grain yield (kg/ha) | Days to 50% flowering | Agronomic score | 100g seed mass | No of plants lodged | No of panicles | Disease score | Seedling vigour |
| GADAM | 1250 | 71 | 2 | 3.5 | 1.5 | 42.5 | 5 | 1 |
| GAMBELLA 1107 | 1998 | 69 | 1 | 3 | 1 | 53.5 | 3 | 1 |
| ICSR 161 | 760 | 71 | 2 | 3.5 | 1.5 | 30 | 5 | 2.5 |
| ICSV 111 IN | 592 | 74 | 2.5 | 2.5 | 1.5 | 34.5 | 3 | 4 |
| IESV 23006 DL | 1358 | 69 | 1.5 | 3 | 1 | 40 | 5 | 1 |
| IESV 23007 DL | 1427 | 62.5 | 2 | 3.5 | 2 | 45 | 5 | 1 |
| IESV 23010 DL | 1662 | 72 | 2 | 3.5 | 1 | 42 | 3 | 2.5 |
| IESV 91070 DL | 710 | 70.5 | 1.5 | 3 | 1.5 | 31.5 | 3 | 4 |
| IESV 91104 DL | 811 | 68 | 2 | 3 | 1.5 | 29.5 | 7 | 2.5 |
| IESV 91111 DL | 1052 | 64.5 | 2.5 | 3.5 | 2 | 49 | 5 | 4 |
| IESV 91131 DL | 1006 | 73 | 2.5 | 3 | 1.5 | 45.5 | 3 | 2.5 |
| IESV 92008 | 1072 | 69 | 2 | 3.5 | 1.5 | 42.5 | 3 | 2.5 |
| IESV 92021 | 686 | 67 | 2 | 3.5 | 1.5 | 34.5 | 7 | 1 |
| IESV 92028 DL | 1955 | 66.5 | 2 | 3 | 1.5 | 30.5 | 3 | 1 |
| IESV 92207 | 1330 | 74.5 | 2 | 3 | 1.5 | 46.5 | 3 | 2.5 |
| IESV 99061 | 688 | 72 | 2.5 | 3 | 1.5 | 30.5 | 4 | 1 |
| KARI MTAMA 1 (Check) | 1751 | 68.5 | 1.5 | 3 | 1 | 39.5 | 5 | 1 |
| KAT 487 | 798 | 73.5 | 2.5 | 3 | 1.5 | 28.5 | 5 | 2.5 |
| Lugugu (Local Check) | 1343 | 77 | 2 | 3 | 1.5 | 41 | 3 | 2.5 |
| MACIA | 1688 | 64 | 2 | 4 | 1.5 | 40 | 3 | 4 |
| PATO | 1380 | 67.5 | 2 | 3 | 1.5 | 41.5 | 3 | 1 |
| SDSI 90167 | 855 | 64 | 2 | 3 | 1 | 46.5 | 4 | 2.5 |
| SIMA | 1379 | 66.5 | 2 | 3 | 1.5 | 38.5 | 3 | 1 |
| TEGEMEO | 1255 | 65 | 2.5 | 3 | 1 | 42.5 | 5 | 1 |
| WA 111 | 821 | 69 | 2.5 | 3 | 2 | 40.5 | 2 | 2.5 |
| Mean | 1185.1 | 68.98 | 2.04 | 3.16 | 1.44 | 39.4 | 4 | 2.08 |
| Fpr | 0.656 | 0.915 | 0.848 | 0.881 | 0.918 | 0.994 | 0.681 | 0.226 |
| sed | 636.639 | 6.458 | 0.6633 | 0.5657 | 0.5657 | 16.07 | 2.062 | 1.342 |
| CV% | 53.7 | 9.4 | 32.5 | 17.9 | 39.3 | 40.7 | 51.5 | 64.5 |

### **3.1.2 Performance during the 2014-15 cropping season**

Results show no significant differences p<0.05 for grain yield, days to 50% flowering, agronomic score, 100g seed mass, number of panicles, number of plants lodged, disease score and seedling vigour (Table 3). Unlike the 2013-14 season, in this season IESVs 23010 and 92028 were the best yielding genotypes with yields of 1923 and 1873kg/ha respectively compared to the two checks with yields of 1635 and 1363 kg/ha for Kari Mtama 1 and Lugugu respectively. Gambella 1107 and IESV 23010 showed better earliness with 65.5 and 66 as Days to 50% flowering compared to 76.7 for Lugugu (check). These genotypes also resisted leaf blight better (<3) than Lugugu which had a disease score of 5 on 1-9 disease rating scale. Kari Mtama 1 a released check had a disease score of 3. In this season the local variety compared well in terms seedling vigour and agronomic scores to the new genotypes. With general the low disease severity, the poor show in yield for the local variety may be genetic. This may also infer great genetic gains (yield gains) made in the new lines being evaluated.

**Table 3 Performance during the 2014-15 cropping season.**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Genotype | grain yield (kg/ha) | days to 50% flowering | Agronomic score | 100g seed mass | no of plants lodged | No of panicles | Disease score | seedling vigour |
| GADAM | 830 | 71 | 2 | 3.5 | 1 | 24 | 5 | 2.5 |
| GAMBELLA 1107 | 1682 | 65.5 | 1 | 3 | 1 | 49.5 | 2 | 1 |
| ICSR 161 | 1273 | 70 | 2 | 3.5 | 1.5 | 46.5 | 5 | 1 |
| ICSV 111 IN | 536 | 69 | 1.5 | 3.5 | 2 | 19.5 | 5 | 1.5 |
| IESV 23006 DL | 1923 | 66 | 1.5 | 3.5 | 1.5 | 35.5 | 2 | 1 |
| IESV 23007 DL | 644 | 70.5 | 3 | 3.5 | 1.5 | 23 | 4.5 | 2.5 |
| IESV 23010 DL | 1652 | 66 | 2 | 4 | 1 | 39.5 | 3 | 1 |
| IESV 91070 DL | 691 | 73.5 | 2 | 3 | 1 | 17.5 | 3 | 3.5 |
| IESV 91104 DL | 761 | 67.5 | 2.5 | 3 | 1.5 | 22.5 | 4.5 | 3.5 |
| IESV 91111 DL | 1005 | 72.5 | 2.5 | 3 | 1.5 | 46 | 4.5 | 2 |
| IESV 91131 DL | 1471 | 69 | 2 | 3 | 1 | 42 | 5 | 2 |
| IESV 92008 | 1486 | 67.5 | 1.5 | 3 | 1 | 43 | 2 | 1 |
| IESV 92021 | 1202 | 66.5 | 1.5 | 3 | 1.5 | 31.5 | 4 | 2.5 |
| IESV 92028 DL | 1873 | 70.5 | 2 | 3 | 1 | 28 | 2 | 2.5 |
| IESV 92207 | 1044 | 75.5 | 2 | 2.5 | 1 | 39 | 7 | 1 |
| IESV 99061 | 610 | 68 | 2 | 3 | 2 | 38.5 | 4.5 | 2.5 |
| KARI MTAMA 1 | 1635 | 63 | 1.5 | 3 | 1 | 44.5 | 3 | 2.5 |
| KAT 487 | 1715 | 67 | 1.5 | 3 | 1 | 42 | 3 | 1 |
| (Lugugu) Local Check | 1363 | 76.7 | 2 | 3 | 2 | 38.5 | 5 | 1 |
| MACIA | 1203 | 68.5 | 2.5 | 4 | 1.5 | 39.5 | 3 | 2.5 |
| PATO | 1931 | 68 | 1.5 | 3 | 1 | 52.5 | 2 | 2.5 |
| SDSI 90167 | 1144 | 69.5 | 2 | 3.5 | 1 | 34.5 | 4 | 4 |
| SIMA | 1347 | 64.5 | 2 | 3 | 1 | 34.5 | 3 | 1 |
| TEGEMEO | 1154 | 70.5 | 2 | 3 | 1.5 | 38.5 | 3.5 | 1 |
| WA 111 | 1062 | 67 | 2.5 | 3 | 1.5 | 36.5 | 1.5 | 1 |
| Mean | 1249.53 | 68.66 | 1.94 | 3.18 | 1.3 | 36.3 | 3.64 | 1.9 |
| Fpr | 0.108 | 0.978 | 0.263 | 0.395 | 0.243 | 0.184 | 0.461 | 0.425 |
| sed | 466.044 | 6.094 | 0.5477 | 0.469 | 0.433 | 11.03 | 1.882 | 1.288 |
| CV% | 37.3 | 8.9 | 28.2 | 14.7 | 33.3 | 30.4 | 51.7 | 67.8 |

### **3.1.3 combined analysis for 2013-14 and 2014-15 cropping seasons**

Results show significant differences p<0.05 for yield but no differences for the rest of the traits (Table 4). All the five genotypes (Gambella 1107, IESV 23010 DL, IESV 23006 DL, IESV 92028 DL and IESV 92008) yielded above the overall mean of 1217.32kg/ha. Overall, IESV 92028 was the best genotype with 1914kg/ha followed by Gambella 1107 which gave a yield of 1840kg/ha. These genotypes had a yield advantage of 13 and 8.7% over Kari Mtama 1 respectively. Some of the new lines (IESV 91070 DL, IESV 91104 DL, IESV 92021, IESV 99061 and ISCV 11 IN) under evaluation yielded below 800kg/ha which underscores the superiority of the five genotypes.

**Table 4 Genotype performance across years**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Genotype | grain yield (kg/ha) | days to 50% flowering | Agronomic score | 100g seed mass | no of plants lodged | No of panicles | Disease score | seedling vigour | Pest score |
| GADAM | 1040 | 71 | 2 | 3.5 | 1.25 | 33.25 | 5 | 1.75 | 3 |
| GAMBELLA 1107 | 1840 | 67.25 | 1 | 3 | 1 | 51.5 | 2.5 | 1 | 3 |
| ICSR 161 | 1017 | 70.5 | 2 | 3.5 | 1.5 | 38.25 | 5 | 1.75 | 3 |
| ICSV 111 IN | 564 | 71.5 | 2 | 3 | 1.75 | 27 | 4 | 2.75 | 3 |
| IESV 23006 DL | 1641 | 67.5 | 1.5 | 3.25 | 1.25 | 37.75 | 3.5 | 1 | 3 |
| IESV 23007 DL | 1035 | 66.5 | 2.5 | 3.5 | 1.75 | 34 | 4.75 | 1.75 | 3 |
| IESV 23010 DL | 1657 | 69 | 2 | 3.75 | 1 | 40.75 | 3 | 1.75 | 3 |
| IESV 91070 DL | 700 | 72 | 1.75 | 3 | 1.25 | 24.5 | 3 | 3.75 | 3 |
| IESV 91104 DL | 786 | 67.75 | 2.25 | 3 | 1.5 | 26 | 5.75 | 3 | 3 |
| IESV 91111 DL | 1029 | 68.5 | 2.5 | 3.25 | 1.75 | 47.5 | 4.75 | 3 | 3 |
| IESV 91131 DL | 1238 | 71 | 2.25 | 3 | 1.25 | 43.75 | 4 | 2.25 | 3 |
| IESV 92008 | 1279 | 68.25 | 1.75 | 3.25 | 1.25 | 42.75 | 2.5 | 1.75 | 2.5 |
| IESV 92021 | 944 | 66.75 | 1.75 | 3.25 | 1.5 | 33 | 5.5 | 1.75 | 3 |
| IESV 92028 DL | 1914 | 68.5 | 2 | 3 | 1.25 | 29.25 | 2.5 | 1.75 | 3 |
| IESV 92207 | 1187 | 75 | 2 | 2.75 | 1.25 | 42.75 | 4.993 | 1.75 | 3 |
| IESV 99061 | 649 | 70 | 2.25 | 3 | 1.667 | 34.5 | 4.25 | 1.75 | 3 |
| KARI MTAMA 1 | 1693 | 65.75 | 1.5 | 3 | 1 | 42 | 4 | 1.75 | 3 |
| KAT 487 | 1257 | 70.25 | 2 | 3 | 1.25 | 35.25 | 4 | 1.75 | 3 |
| Local Check | 1353 | 78.5 | 2 | 3 | 1.75 | 39.75 | 4 | 1.75 | 3 |
| MACIA | 1445 | 66.25 | 2.25 | 4 | 1.5 | 39.75 | 3 | 3.25 | 3 |
| PATO | 1655 | 67.75 | 1.75 | 3 | 1.25 | 47 | 2.5 | 1.75 | 2.5 |
| SDSI 90167 | 1000 | 66.75 | 2 | 3.25 | 1 | 40.5 | 4 | 3.25 | 3 |
| SIMA | 1363 | 65.5 | 2 | 3 | 1.25 | 36.5 | 3 | 1 | 3 |
| TEGEMEO | 1205 | 67.75 | 2.25 | 3 | 1.25 | 40.5 | 4.25 | 1 | 3 |
| WA 111 | 942 | 68 | 2.5 | 3 | 1.75 | 38.5 | 1.75 | 1.75 | 3 |
| Mean | 1217.32 | 68.82 | 1.99 | 3.17 | 1.367 | 37.9 | 3.82 | 1.99 | 2.96 |
| Fpr | 0.007 | 0.869 | 0.102 | 0.091 | 0.296 | 0.317 | 0.174 | 0.212 | 0.528 |
| sed | 359.026 | 4.011 | 0.3979 | 0.3291 | 0.3356 | 8.87 | 1.299 | 0.946 | 0.2 |
| CV% | 41.7 | 8.2 | 28.3 | 14.7 | 34.7 | 33.1 | 48.1 | 67.2 | 9.6 |

### **3.1.4 Genotype x Environment interaction**

The genotype x year (environment) results show genotype effects being significant p<0.05 for yield but no differences observed for years and genotype x year interaction for all traits (Table 5). This imply that season did not have any influence on the performance of the genotypes. The genotype x year plot shows 2013-14 as a better year than 2014-15 season and most genotypes performing better in this year (Fig 3). IESV 92010 was amongst the most stable genotypes. Lugugu (local check) though with low yields was also very stable. The local check has consistently given very high days to 50% flowering (>77 days) which means it is long duration and may not fit well with the existing climate variations in the Region and may likely be reason for poor performance in terms of grain yield. Results may also imply that the difference in performance shown by genotypes across years is largely genetic.

**Table 5** **Genotype x Environment (year) interaction**

|  |  |  |  |
| --- | --- | --- | --- |
| Genotype | Grain yield (kg/ha) | days to 50% flowering | No of panicles |
| GADAM | 1040 | 71 | 33.25 |
| GAMBELLA 1107 | 1840 | 67.25 | 51.5 |
| ICSR 161 | 1017 | 70.5 | 38.25 |
| ICSV 111 IN | 564 | 71.5 | 27 |
| IESV 23006 DL | 1641 | 67.5 | 37.75 |
| IESV 23007 DL | 1035 | 66.5 | 34 |
| IESV 23010 DL | 1657 | 69 | 40.75 |
| IESV 91070 DL | 700 | 72 | 24.5 |
| IESV 91104 DL | 786 | 67.75 | 26 |
| IESV 91111 DL | 1029 | 68.5 | 47.5 |
| IESV 91131 DL | 1238 | 71 | 43.75 |
| IESV 92008 | 1279 | 68.25 | 42.75 |
| IESV 92021 | 944 | 66.75 | 33 |
| IESV 92028 DL | 1914 | 68.5 | 29.25 |
| IESV 92207 | 1187 | 75 | 42.75 |
| IESV 99061 | 649 | 70 | 34.5 |
| KARI MTAMA 1 (Released check) | 1693 | 65.75 | 42 |
| KAT 487 | 1257 | 70.25 | 35.25 |
| Lugugu (Local Check) | 1353 | 77.7 | 39.75 |
| Macia | 1445 | 66.25 | 39.75 |
| PATO | 1655 | 67.75 | 47 |
| SDSI 90167 | 1000 | 66.75 | 40.5 |
| SIMA | 1363 | 65.5 | 36.5 |
| TEGEMEO | 1205 | 67.75 | 40.5 |
| WA 111 | 942 | 68 | 38.5 |
| Mean | 1217.32 | 68.82 | 37.9 |
| Fpr genotype | 0.044 | 0.947 | 0.541 |
| Fpr year | 0.566 | 0.8 | 0.254 |
| Fpr genotype x year | 0.97 | 0.978 | 0.982 |
| sed | 557.901 | 6.279 | 9.75 |
| CV% | 45.8 | 9.1 | 36.4 |



**Fig 3 genotype x year biplot**

## **3.2. On farm evaluation of genotypes**

### **3.2.1 Farmers’ traits**

For on farm testing, genotypes were evaluated in a participatory approach with farmers from Moleti, Laikala in Kongwa District, Njoro and Kiperesa in Kiteto District and Igula in Iringa District. A mother baby approach was used, with at least two mother and four baby sites per village. About 30 farmers hosted a mother site each with 2 baby sites located in a radius of about 5km from the mother sites. Data from baby sites was mostly farmers’ preference of the new genotypes. Field days, regular farmer-researcher meetings were used to collect preference data. Focus group discussions were used to understand what farmers look for in varieties. Farmers were also given chance to rank genotypes based own chosen criteria (Table 6, Plate 3). Through focus group discussions, the most important traits for women were; drought tolerance, earliness and panicle size in order of priority and for men included panicle size, number of tillers and earliness in order of preference. Colour was not of importance as farmers indicated that they use both brown, white and red sorghum for *Ugali* (hard porridge) and uji (porridge) with red sorghum being the most preferred for *uji*. Farmers also indicated that in the current trend, there isn’t any difference in preference based on colour by buyers or traders. Women farmers also expressed dislike for tall varieties which they say pose difficulties during harvesting.

**Table 6 Farmer selection of traits**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Women |  |  | Men |  |  |
| Traits | **Scores** | **Rank** | **Traits** | **Scores** | **Rank** |
| Early maturing | 55 | 2 | Drought tolerant | 20 | 3 |
| panicle size | 64 | 3 | Early maturing | 22 | 2 |
| Drought tolerant | 71 | 1 | Panicle size | 37 | 1 |
| p/disease tolerant | 19 | 6 | Seed size | 20 | 3 |
| seed size | 51 | 5 | Colour | 20 | 3 |
| Colour | 19 | 7 | Number of tillers | 37 | 1 |
| Plant height | 44 | 4 |  |  |  |
| Total participants | 323 |  |  | 119 |  |

### **3.2.2 Performance during the 2013-14 cropping season**

In this season, four (4) genotypes were evaluated against three checks at Moleti and Laikala, the two driest villages of the seven villages. Main data collected included grain yield, 100g seed mass and farmer preferences. Significant differences p<0.05 were observed for both grain yield and 100g seed mass (Table 7). Though the season had generally low yields, IESV 23010 DL and Gambella were the best yielding genotypes with 1333.3 and 1272.1kg/ha respectively compared to the two checks that yielded 798.2 and 696.6 kg/ha for Kari Mtama 1 and Lugugu respectively. Macia, also a released variety in Tanzania equally yielded below the three new genotypes. The two had a yield advantage over Kari Mtama 1 of 91.4 and 82.62 respectively. Gambella 1107 also expressed the highest 100g seed mass (3.35g). Farmer scores for varieties were recorded as individual counts against each genotype and then ranked based on most counts. The main traits farmers used to evaluate genotypes were panicle size, seed size, drought tolerance and earliness. Even though Gambella 1107 and IESV 92028 DL had lower yields than IESV 23010, the two were the most preferred genotypes with the most scores of 145 and 141 respectively. The genotype x environment biplot shows that the genotypes performed better in Laikala than Moleti (Fig 4). Genotypes spread show no particular preference to sites, however, Gambella 1107 shows to be the most stable genotype.

**Table 7 performance during the 2013-14 cropping season**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Genotype | Grain yield/ha | 100g seed mass | % Yield advantage | Scores | Rank | Reasons |
| Gambella 1107 | 1272.1 | 3.35 | 82.62 | 145 | 1 | Panicle size, seed size, earliness |
| GHUM ICSV | 747.1 | 2.45 | 7.24 | 122 | 4 | earliness |
| IESV 23010 DL | 1333.3 | 3.0 | 91.4 | 134 | 3 | Panicle size, earliness, drought |
| Macia | 858.3 | 2.2 | 23.21 | 77 | 6 | earliness |
| IESV 92028 DL | 1144.5 | 2.7 | 64.29 | 141 | 2 | Panicle size, earliness, drought |
| KARI MTAMA (Released check) | 798.2 | 2.2 | 14.58 | 87 | 5 | earliness |
| Lugugu (Local check) | 696.6 | 2.4 |  | 12 | 7 |  |
| Mean | 979 | 2.4 |  |  |  |  |
| Fpr | 0.013 | <.001 |  |  |  |  |
| sed | 146.1 | 0.378 |  |  |  |  |
| CV% | 14.9 | 1.6 |  |  |  |  |



**Fig 4 Genotype x Environment biplot**

### **3.2.3 Performance during the 2014-15 cropping season**

Four (4) genotypes were for the second season running tested in Laikala and Moleti against two released varieties (Kari Mtama 1 and Macia) and a local check (Lugugu). Significant differences p<0.05 were observed for both grain yield and 100g seed mass. IESV 23010 DL was the best yielding genotype giving 2141kg/ha (Table 8). Of the three checks, only Macia competed well with the other three test lines. The yield advantages over Kari Mtama 1 for the new genotypes ranged from 46.88 to 151.58%. Gambella 1107 continued to expressed good seed size with a 100g seed mass of 3.2g. The genotype x environment interaction shows Laikala as the better environment than Moleti with Gambella 1107 and Kari Mtama 1 as the most stable genotype (Fig 5). The biplot also shows that IESV 23010 DL yielded better in Moleti than Laikala as such, was specific to this environment. Overall ranking of genotypes showed IESV 23010 DL as the most preferred genotype with a total score of 89. The genotype was selected for its large panicle sizes and ability to tolerate drought. This was followed by Gambella 1107 and Macia with scores of 79 and 78 respectively. From the farmer rating of genotypes, it shows that panicle size and drought tolerant were the key traits for selecting genotypes.

**Table 8 Performance during the 2014-15 cropping season**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Genotype | grain yield/ha | 100g seed mass | Yield advantage | Scores | Rank | Reasons |
| Gambella 1107 | 1262 | 3.2 | 48.29 | 79 | 2 | Panicle size, drought tolerant |
| GHUM ICSV | 1259 | 2.6 | 47.94 | 34 | 5 | Panicle size |
| IESV 23010 DL | 2141 | 3.0 | 151.58 | 89 | 1 | Panicle size drought tolerant |
| IESV 92008 DL | 1250 | 2.2 | 46.88 | 55 | 4 | Panicle size, earliness |
| MACIA | 1346 | 2.2 | 58.17 | 78 | 3 | Panicle size, drought tolerant |
| KARI MTAMA 1 (Released check) | 851 | 2.2 |  | 27 | 6 | drought tolerant |
| Lugugu (Local check) | 576 | 2.4 |  | 12 | 7 |  |
| Mean | 1241 | 24 |  |  |  |  |
| Fpr | 0.02 | <.001 |  |  |  |  |
| sed | 290.2 | 0.453 |  |  |  |  |
| CV% | 23.4 | 5.4 |  |  |  |  |



**Fig 5 Genotype x Environment biplot**

### **3.2.4 Combined analysis for 2014-14 and 2014-15 cropping seasons**

Overall analysis for the two seasons shows significant differences p<0.05 for both grain yield and 100g seed mass (Table 9). Kari Mtama 1, yielded lower than Lugugu as such yield comparisons were made against the farmer variety. IESV 92028 DL was the overall best in terms of grain yield (1643kg/ha) with a yield advantage over the check (Lugugu) of 68.85%. IESV 23010 DL was the best in terms of seed size (3.0g) followed by Gambella 1107 (2.55g). As expressed in the individual seasons, Laikala remains the better environment with Gambella 1107 as the most stable genotype (Fig 6).

**Table 9 Combined analysis for 2014-14 and 2014-15 cropping seasons**

|  |  |  |  |
| --- | --- | --- | --- |
| Genotype | grain yield/ha | 100g seed mass | % Yield advantage |
| Gambella 1107 | 1267 | 2.75 | 30.22 |
| GHUM ICSV | 1003 | 2.55 | 3 |
| IESV 23010 | 1340 | 3.0 | 37.7 |
| Macia | 1102 | 2.2 | 13.25 |
| IESV 92028 | 1643 | 2.2 | 68.85 |
| KARI MTAMA (Released check) | 825 | 2.2 | -15.21 |
| Lugugu (Local check) | 973 | 2.4 |  |
| Mean | 1110 | 2.4 |  |
| Fpr | 0.012 | <.001 |  |
| sed | 238.2 | 0.3619 |  |
| CV% | 30.4 | 2.1 |  |



**Fig 6 Genotype x Environment biplot**

### **3.2.5 Performance during the 2015-16 cropping season**

In this season three (3) genotypes (Gambella 1107, IESV 23010 DL and IESV 92028 DL) were evaluated in three environments of Laikala, Moleti and Igula against a local check. Data collected included grain yield, number of ears and farmer preferences. Significant differences, p<0.05 were observed for grain yield but not number of ears which may mean the difference in grain yield might have been due to variations in the weight itself (Table 10). In this season, genotypes yielded better than the two preceding seasons with a mean sites yield of 2498.4kg/ha. Gambella 1107 was the best yielding genotype (3380kg/ha) with a yield advantage of 100.23% over the local check. All the new lines yielded better than the local check and two of which had mean yields above the site mean. Gambella 1107 was the most preferred genotype followed by IESV 92028 DL with scores of 215 and 155 respectively. Large panicle size and ability to withstand drought were the main reasons for selecting Gambella 1107 while large panicle size and earliness were the reasons for choosing IESV 92028 DL. The genotype x environment biplot shows Moleti and Igula as better environments than Laikala with Gambella 1107 as the best genotype as show by its positive index on the graph but also as the most stable genotype (Fig 7). The biplot also shows that Gambella 1107 performed better in Moleti and Igula while IESVs 23010 DL and 92028 DL yielded better in Laikala.

**Table 10 Performance during the 2015-16 cropping season**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Genotype | grain yield (kg/ha) | No of ears | Yield advantage | Scores | Rank | Reasons |
| Gambella 1107 | 3380 | 159.9 | 100.23 | 215 | 1 | Panicle size, seed size, drought |
| IESV 23010 DL | 2308 | 159.5 | 36.7 | 137 | 3 | Panicle size, earliness |
| IESV 92028 DL | 2470 | 175.2 | 46.32 | 155 | 2 | Panicle size, earliness |
| Lugugu (Check) | 1688 | 152.3 |  | 45 | 4 | Drought |
| Mean | 2498.4 | 161.6 |  |  |  |  |
| Fpr | <.001 | 0.154 |  |  |  |  |
| sed | 227.75 | 9.42 |  |  |  |  |
| CV% | 16.4 | 10.5 |  |  |  |  |



**Fig 7 Genotype x Environment biplot**

### **3.2.6 Performance during the 2016-17 cropping season**

In this season, the three genotypes were again evaluated in Moleti, Laikala and Igula against Lugugu a local check with grain yield, number of ears and farmer preferences as the main data. Significant differences, p<0.05, were observed for both grain yield and number of ears (Table 11). Genotype performance was as good as the 2015-16 season with a mean site yield of 3950.3 kg/ha. Gambella 1107 gave the highest yield of 4604kg/ha followed by IESV 92028 DL with a yield of 4080kg/ha and both above the site mean. The two genotypes gave a yield advantage over the local check of 44.14 and 27.73 % respectively. Even though the number of ears varied across genotypes, results show that they didn’t contribute to variation in yield as the highest yielding genotype (Gambella1107) had the least number of ears. The genotype x environment biplot shows Moleti and Laikala as the better environments than Igula with Gambella 1107 as the best genotype but IESV 23010 DL as the most stable genotype (Fig 8). IESV 92028 DL showed to be specific to Igula meaning the overall high yield observed for this genotype might have had influence from this site. Participatory Variety Selection ranks the genotypes as Gambella 1107, IESV 92028 DL and IESV 23010 DL in order of preferences with panicle size as the key trait for selection.

**Table 11 On Performance during the 2016-17 cropping season**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Genotype | grain yield (kg/ha) | No of ears | Yield advantage | Scores | Rank | Reasons |
| Gambella 1107 | 4604 | 124.8 | 44.14 | 117 | 1 | Panicle size, seed size |
| IESV 23010 | 3923 | 160.5 | 22.82 | 99 | 3 | Panicle size |
| IESV 92028 | 4080 | 180.2 | 27.73 | 104 | 2 | Panicle size |
| Lugugu (Check) | 3194 | 166 |  |  |  |  |
| Mean | 3950.3 | 157.9 |  |  |  |  |
| Fpr | 0.017 | 0.003 |  |  |  |  |
| sed | 398.54 | 13.05 |  |  |  |  |
| CV% | 17.5 | 14.3 |  |  |  |  |



**Fig 8 Genotype x Environment biplot**

### **3.2.7 Combined analysis for 2015-16 and 2016-17 cropping seasons**

To assess the effect of environment (season), a combined analysis for the two traits (grain yield and number of ears) was performed. Significant differences, p<0.05 were observed for both grain yield and number of ears (Table 12). The overall mean was 3176.7kg/ha and two genotypes; Gambella 1107 and IESV 92028 DL gave yields above the two years’ mean. All the three new genotypes had a positive yield advantage over the local check ranging from 27.65 to 58.75%. The genotype x year (environment) does not show much differences between the two years but the 2015-16 season had slightly better yields than the 2016-17 season (Fig 9). 2016-17 season had generally lower annual rainfall compared to 2015-16 season (App 1) and this may have contributed to the relatively lower yields. All the three new genotypes showed to be more stable across the seasons than the local check.

**Table 12 Combined analysis for 2015-16 and 2016-17 seasons**

|  |  |  |  |
| --- | --- | --- | --- |
| Genotype | Grain yield (kg/ha) | % Yield advantage | No of ears |
| Lugugu (Check) | 2441 | 0 | 159.2 |
| Gambella 1107 | 3875 | 58.75 | 145.8 |
| IESV 23010 | 3116 | 27.65 | 160 |
| IESV 92028 | 3275 | 34.17 | 177.7 |
| Mean | 3176.7 |  | 160.7 |
| Fpr | 0.007 |  | 0.008 |
| sed | 386.96 |  | 8.73 |
| CV% | 29.8 |  | 13.3 |



**Fig 9 Biplot for two seasons (2015-16 x 2016-17)**

# **4.0 Conclusions**

After 2 years of on station testing and 4 years of on farm evaluation, 5 genotypes have shown a lot of promise and may be consider for release. These genotypes include; Gambella 1107, IESV 23010 DL, IESV 92028 DL, IESV 23006 DL and IEVS 92008 with yields of up to 4000kg/ha in good seasons (2015-16 and 2016-17) and up to 2000kg/ha in bad seasons (2013-14 and 2014-15). These genotypes had yield advantages over Kari Mtama 1 (a released check) of up to 60% and up to 100% over Lugugu, a local check, except for one season where the local check out performed Kari Mtama 1. With annual rainfall ranging between 98 to 227mm, these varieties have shown to be key for these vulnerable environments and their release could contribute massively to improving food, income and nutrition security for the Region. These will also help farmers quickly decide to shift towards sorghum from the less stable maize as the new sorghum genotypes have shown to be both high yielding and resilient to the harsh environment. Farmer preferences consistently put these genotypes above the all local checks. The genotype x environment biplots served to help map appropriate deployment of the genotypes but the continuous interchange in performance of the genotype across the villages and seasons shows that the five (5) selected genotypes are well adapted to these drought prone villages and may well be deployed to other Regions sharing similar climatic conditions.

# **5.0 Appendices**

**Appendix 1: Four-year rainfall data for Kongwa and Kiteto**

 

**Plate 2 meeting with Iringa District Council Plate 3: Dr Ringo in focus group discussions with farmers**



**Plate 3: tall local variety vs short improved genotype**

**Appendix 2 Members of the Research Team**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Name | Sex | Institution | Telephone | Role in R&D activities |
| Patrick Okori | M | ICRISAT | +265996777683 | Principal investigator. Design and oversight of the project activities |
| Wills Munthali | M | ICRISAT | +265999420251 | Research associate-breeding. Managing; Trial set up (on farm and on station experimentation), Community seed banks and FRNs. |
| Peter Ngowi | M | ICRISAT | +255713302618 | Research Associate: Co-coordinating Project activities |
| Elirehema Swai | M | ARI Hombolo | +255754542340 | Scientist for soil and water management. He is our link to farmers who are part of the FRN (Host Institute) |
| District Councils |  | Kongwa, Kiteto and Iringa |  | Host Districts, providing lead on policy, Innovation platform members |

**Appendix 3. Results of soil sample analysis for Kongwa and Kiteto**

|  |
| --- |
| **Reference Methods:** pH (CaCl2-1:2.5),Walkley-Black method, Acetate, DTPA extraction, hydrometer method for texture |
| Source: Moleti, Mlali, Laikala, Njoro |

**RESULTS:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Lab No.** | **Farmer** | **Trial** | **Sample No.** | **Depth (cm)** | **Coordinates** | **Elevation** | **pH (CaCl2)** | **OC (%)** | **OM (%)** | **EN (%)** | **P**  **ppm** | **K**  **Meq. %** | **Ca**  **Meq. %** | **Mg**  **Meq. %** | **Texture**  **Class** |
| **40410** | Janet Maleng’a | Baby | 1 | 2 | S=0610979  E=03648285 | 1267 | 5.19 | **0.17** | **0.34** | **0.02** | 36.11 | **0.53** | **2.52** | **0.94** | LS |
| **40411** | Winie Saigodi | Baby | 2 | 2 | S=0610210  E=03648233 | 1266 | 4.85 | **0.14** | **0.28** | **0.01** | 17.15 | **0.48** | **2.10** | **0.64** | LS |
| **40412** | Faith Mahingusa | Baby | 3 | 2 | S=0610988  E03648147 | 1262 | 5.26 | **0.31** | **0.62** | **0.03** | 7.13 | **0.68** | **3.26** | **1.21** | SL |
| **40413** | Msafira | Baby | 4 | 2 | S=0611564  E=03648873 | 1287 | 5.69 | **0.34** | **0.68** | **0.03** | 17.07 | **0.84** | **4.14** | **1.59** | SL |
| **40414** | Moleni Mafuso | Baby | 5 | 2 | S=0610324  E=03648980 | 1282 | 5.91 | **0.11** | **0.23** | **0.01** | 28.83 | **0.77** | **2.78** | **0.71** | LS |
| **40415** | Prisca self | Mother | 6 | 2 | S=0608928  E=03648167 | 1280 | 5.88 | **0.45** | **0.91** | **0.05** | 29.81 | **1.37** | **5.64** | **1.96** | SCL |
| **40416** | Michael Chityange | Baby | 7 | 2 | S=0609329  E=03648362 | 1272 | 5.92 | **0.98** | **1.99** | **0.10** | 7.74 | **2.59** | **9.16** | **2.08** | SL |
| **40417** | Mariam Lebwanya | Baby | 8 | 2 | S=0611951  E=03636330 | 1159 | 5.30 | **0.42** | **0.85** | **0.04** | 21.24 | **0.89** | **3.42** | **1.23** | SCL |
| **40418** | Samuel Mjoeni | Baby | 9 | 2 | S=0611026  E=03636919 | 1192 | 5.40 | **0.31** | **0.62** | **0.03** | 13.28 | **0.74** | **2.78** | **1.14** | SL |
| **40419** | Mwajob Self | Baby | 10 | 2 | S=0611656  E=.3635622 | 1150 | 5.47 | **0.45** | **0.91** | **0.05** | 11.68 | **1.15** | **3.42** | **1.44** | SL |
| **40420** | Ester Malole | Baby | 11 | 2 | S=0613009  E=03637696 | 1200 | 5.23 | **0.67** | **1.36** | **0.07** | 4.70 | **1.11** | **3.28** | **1.43** | SL |
| **40421** | Sekwawo Mulusu | Baby | 12 | 2 | S=0612339  E=03637437 | 1200 | 5.36 | **0.36** | **0.74** | **0.04** | 5.61 | **0.66** | **3.08** | **1.27** | SCL |
| **40422** | Eda Masegele | Baby | 13 | 2 | S=0611490  E=03637209 | 1187 | 5.13 | **0.48** | **0.97** | **0.05** | 6.22 | **0.87** | **3.32** | **1.22** | SCL |
| **40423** | Laikala | Mother | 14 | 2 | S=0611522  E=03636985 | 1196 | 5.15 | **0.45** | **0.91** | **0.05** | 7.97 | **1.28** | **4.10** | **1.55** | SCL |
| **40424** | Janet Malangula | Baby | 15 | 10 | S=0610979  E=03648285 | 1267 | 4.37 | **0.08** | **0.17** | **0.01** | 29.81 | **0.47** | **1.68** | **0.43** | LS |
| **40425** | Winnie Saigodi | Baby | 16 | 10 | S=0610210  E=03648233 | 1266 | 4.68 | **0.08** | **0.17** | **0.01** | 16.08 | **0.45** | **2.46** | **0.64** | LS |
| **40426** | Faith Malungula | Baby | 17 | 10 | S=0610988  03648147 | 1262 | 5.28 | **0.31** | **0.62** | **0.03** | 15.10 | **0.85** | **3.22** | **1.17** | LS |
| **40427** | Msafira Malang’a | Baby | 18 | 10 | S=0611564  E=03648873 | 1287 | 5.95 | **0.28** | **0.57** | **0.03** | 32.92 | **0.65** | **2.64** | **1.01** | LS |
| **40428** | Moleni Mafuso | Baby | 19 | 10 | S=0610324  E=03648980 | 1282 | 5.64 | **0.17** | **0.34** | **0.02** | 22.23 | **0.58** | **2.32** | **0.71** | LS |
| **40429** | Prisca Self | Mother | 20 | 10 | S=0608928  E=03648167 | 1280 | 5.89 | **0.56** | **1.14** | **0.06** | 11.76 | **1.48** | **3.36** | **2.30** | SCL |
| **40430** | Michael Chityaunge | Baby | 21 | 10 | S=0609329  E=03648362 | 1272 | 6.01 | **0.81** | **1.65** | **0.08** | 11.30 | **2.63** | **8.96** | **2.09** | SL |
| **40431** | Miriam Lebwanya | Baby | 22 | 10 | S=0611951  E=03636330 | 1159 | 4.97 | **0.50** | **1.02** | **0.05** | 7.74 | **1.23** | **4.40** | **1.68** | SC |
| **40432** | Samuel Mjoeni | Baby | 23 | 10 | S=0611026  E=03636919 | 1192 | 5.22 | **0.36** | **0.74** | **0.04** | 8.12 | **0.72** | **3.52** | **1.16** | SL |
| **40433** | Mwajob Self | Baby | 24 | 10 | S=0611656  E=03635622 | 1150 | 5.29 | **0.42** | **0.85** | **0.04** | 5.99 | **0.99** | **2.90** | **1.56** | SL |
| **40434** | Ester malole | Baby | 25 | 10 | S=0613009  E=03637696 | 1200 | 5.24 | **0.45** | **0.91** | **0.05** | 8.88 | **1.09** | **2.74** | **1.44** | SL |
| **40435** | Sekwawo Mulusu | Baby | 26 | 10 | S=0612339  E=03637437 | 1204 | 5.39 | **0.34** | **0.68** | **0.03** | 9.48 | **0.72** | **2.92** | **1.22** | SCL |
| **40436** | Eda Masegele | Baby | 27 | 10 | S=0611490  E=03637209 | 1187 | 5.02 | **0.45** | **0.91** | **0.05** | 9.41 | **0.88** | **3.88** | **1.16** | SL |
| **40437** | Lai Kala | Mother | 28 | 10 | S=0611522  E=03636988 | 1196 | 5.19 | **0.48** | **0.97** | **0.05** | 11.23 | **1.27** | **4.14** | **1.62** | SL |

1. See <https://www.climatedata.eu/climate.php?loc=tzzz0019&lang=en>. [↑](#footnote-ref-1)
2. See [www.Mcknight.org](http://www.Mcknight.org) for details [↑](#footnote-ref-2)